Transient nature of the Earth's climate and the implications for the interpretation of benthic $\delta^{18}O$ records

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Separating the benthic $\delta^{18}O$ signal

$\delta^{18}O$ data from benthic foraminifera contains 2 main signals:

Local deep-water temperature

influences the degree of uptake of ^{18}O in calcite shell

lower T_{dw} → higher benthic $\delta^{18}O$

Ice Volume

Influences $\delta^{18}O$ of the ocean water (δ_w), evaporation favours light water molecules (e.g. $H_2{}^{16}O$) **more ice → higher benthic $\delta^{18}O$**

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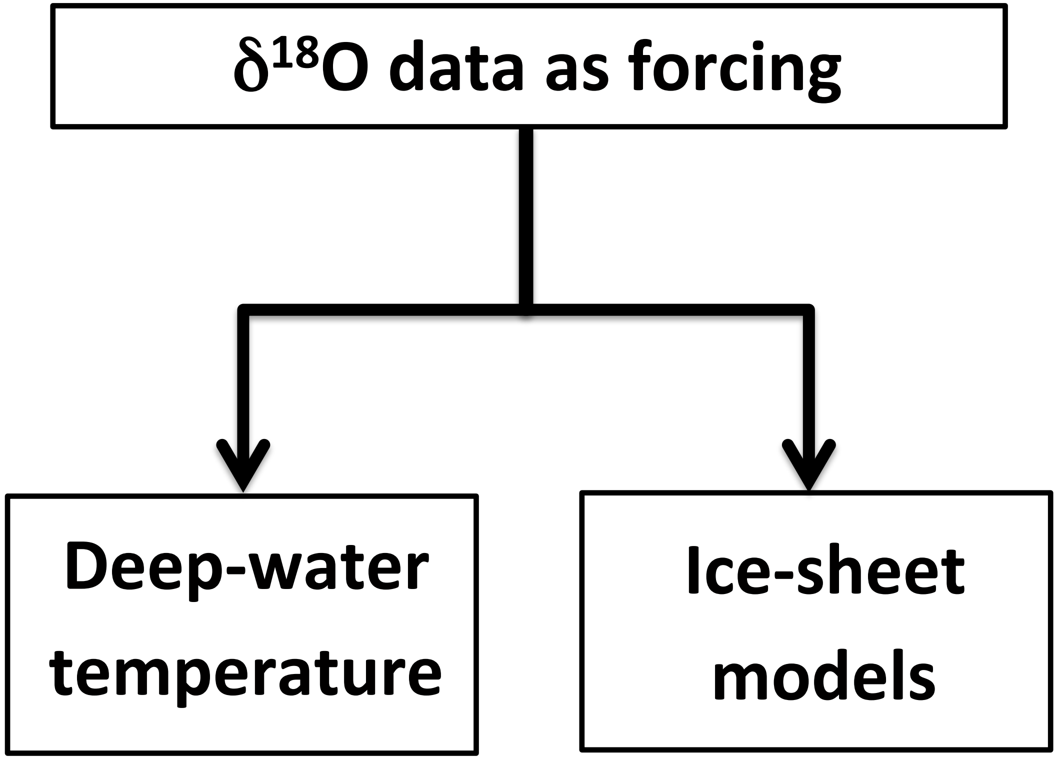
Modelling oxygen isotopes



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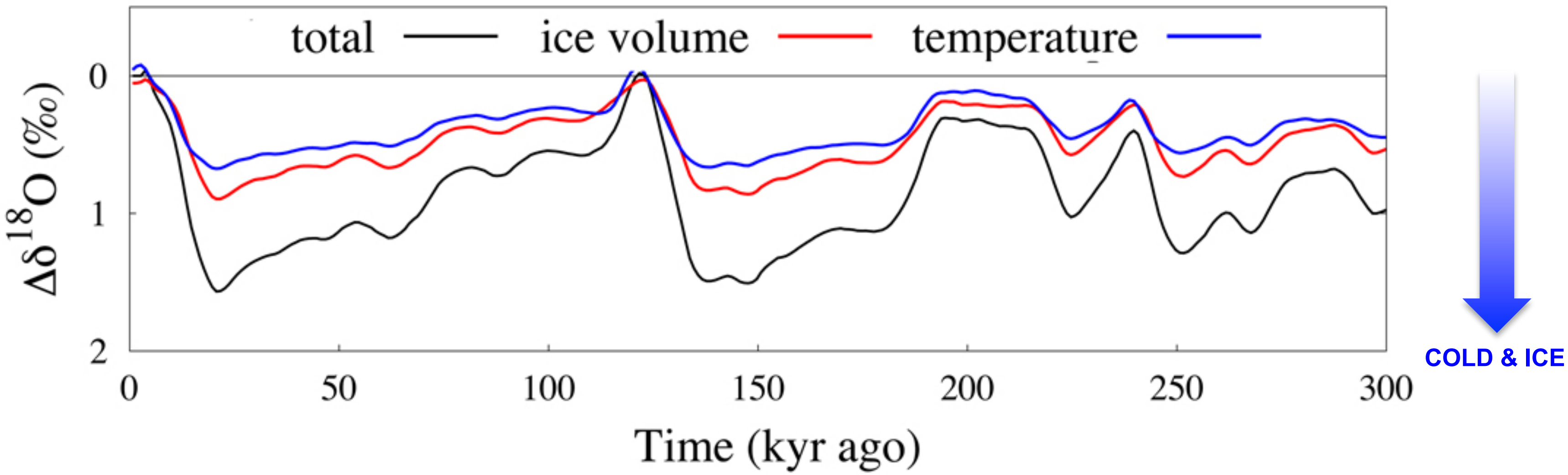
Separating the benthic δ18O signal

Ice volume

Temperature

$$\Delta\delta^{18}O_b = \left[\frac{\overline{\delta^{18}O_iV_i}}{V_o}\right]_{PD} - \frac{\overline{\delta^{18}O_iV_i}}{V_o} + \gamma\Delta T_o$$



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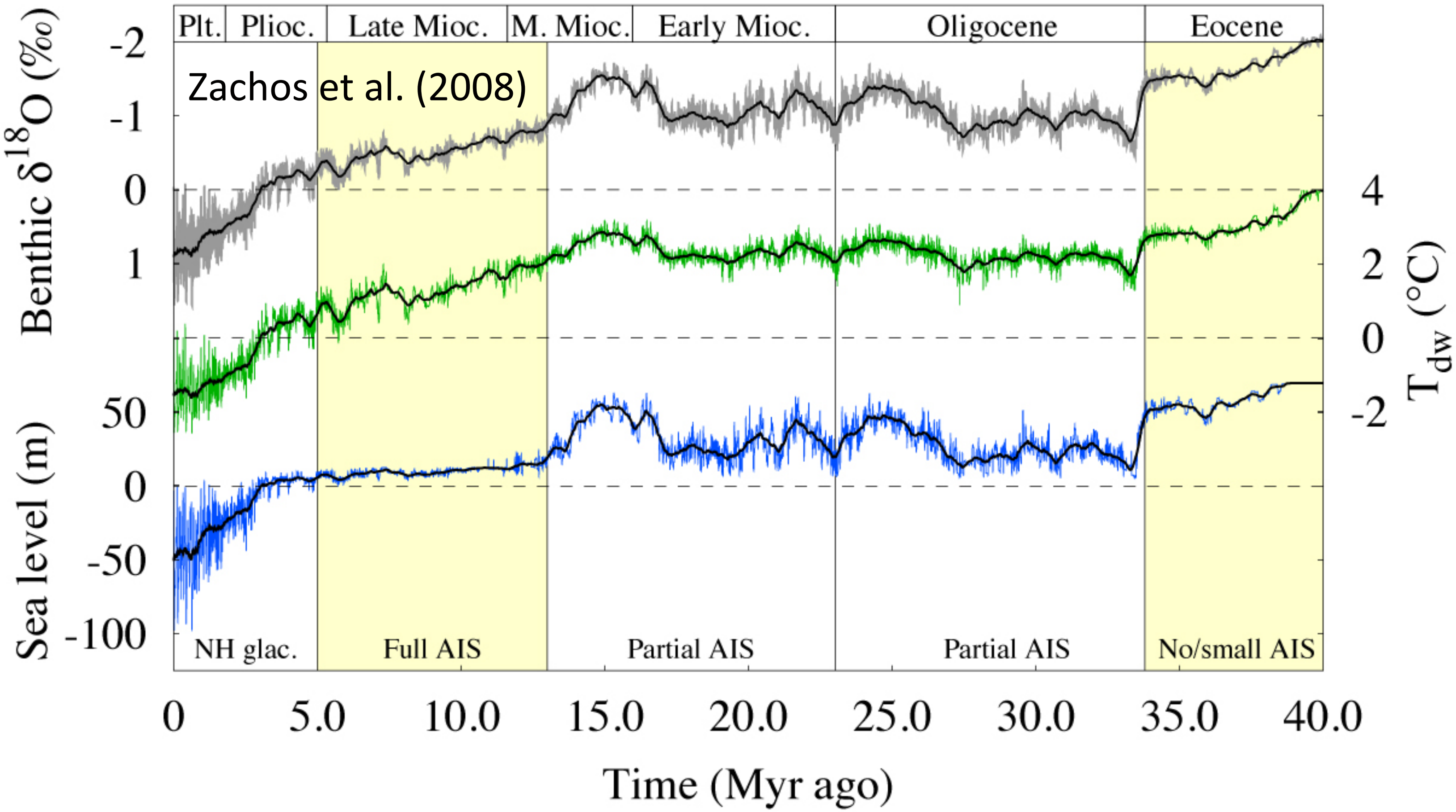
Reconstruction of temperature and sea level

Values are relative to present day!



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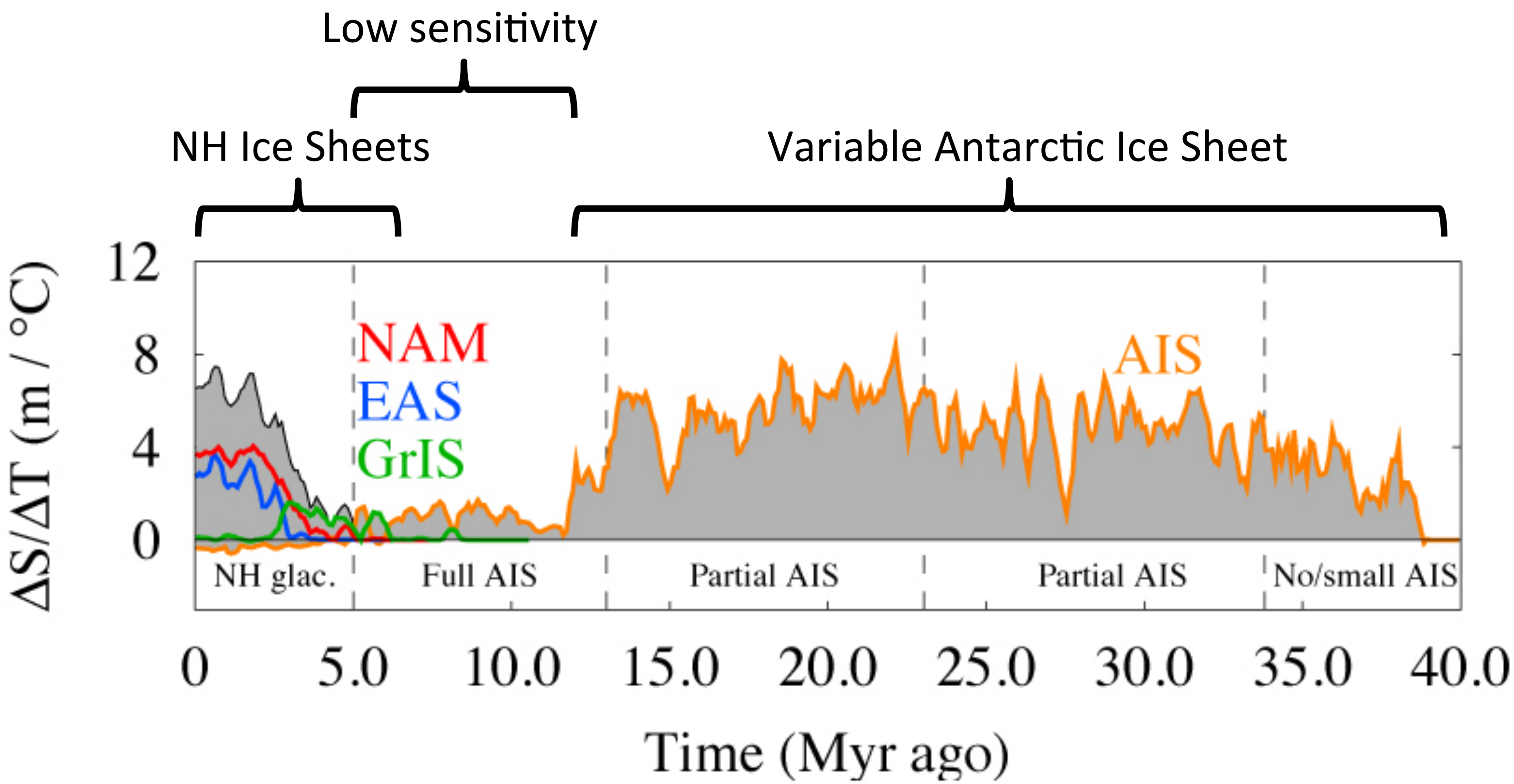
Sea level sensitivity to temperature

ΔS/ΔT (m/°C)

Transition from SH to NH ice



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Assessing the uncertainty in $\delta^{18}O_{ice}$

Some values from the literature for the present day Mean ice-sheet $\delta^{18}O_i$

Ice sheet	**Min $\delta^{18}O$**	**Max $\delta^{18}O$**
East Antarctic Ice Sheet	**-55**[a]	**-43**[b]
West Antarctic Ice Sheet	**-42**[a]	**-32**[b]
Greenland Ice Sheet	**-36**[c]	**-28**[d]

[a]*Lhomme et al. (2005)*
[b]*Giovinetto and Zwally (1997)*
[c]*Duplessy et al. (2002)*
[d]*Zwally and Giovinetto (1997)*

$$\delta^{18}O_i = \delta^{18}O_{pd} + \beta_T \Delta T + \beta_Z \Delta Z$$

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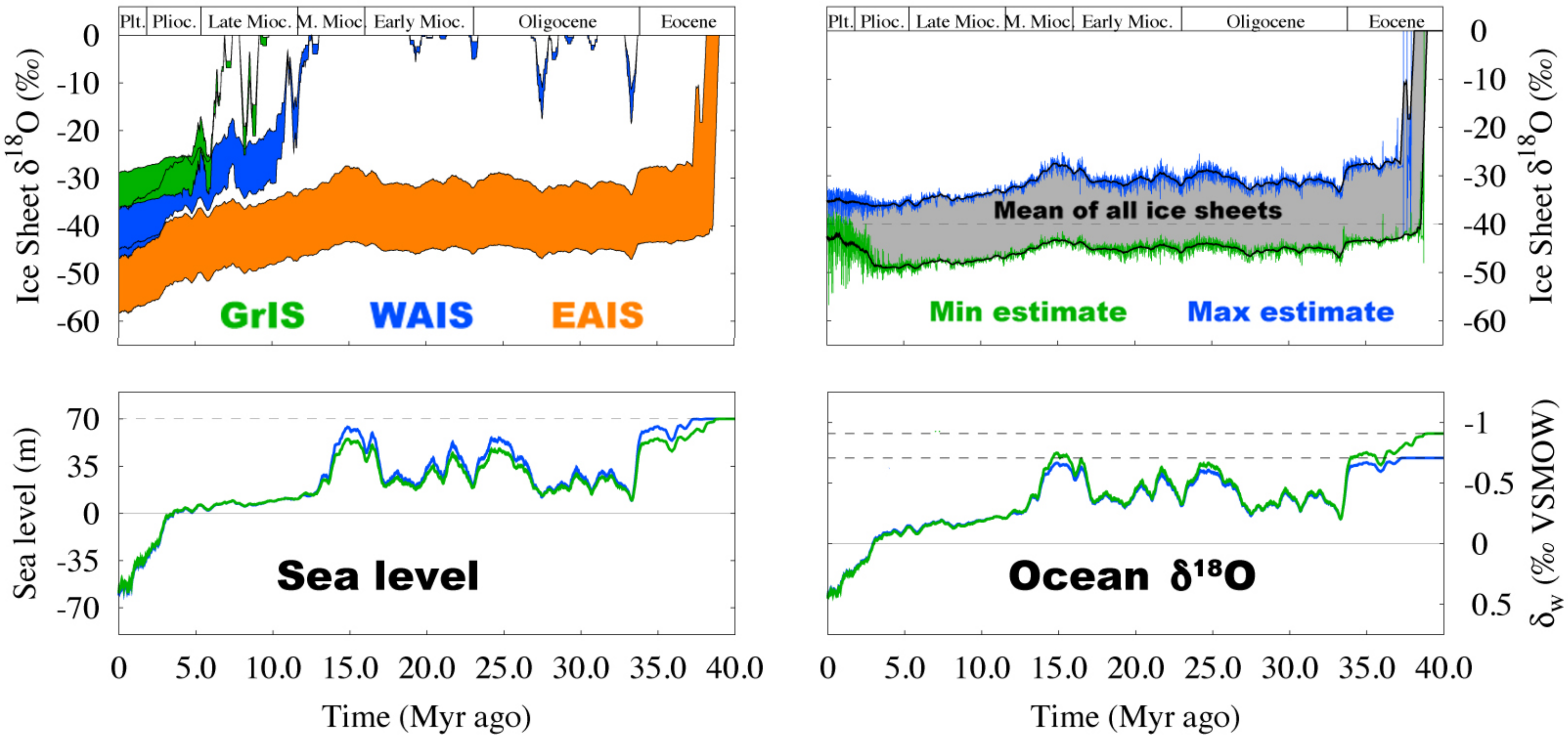
Uncertainty range in $\delta^{18}O_{ice}$



Uncertainty is quite significant in model, however..

differences are small for sea level and ocean $\delta^{18}O$

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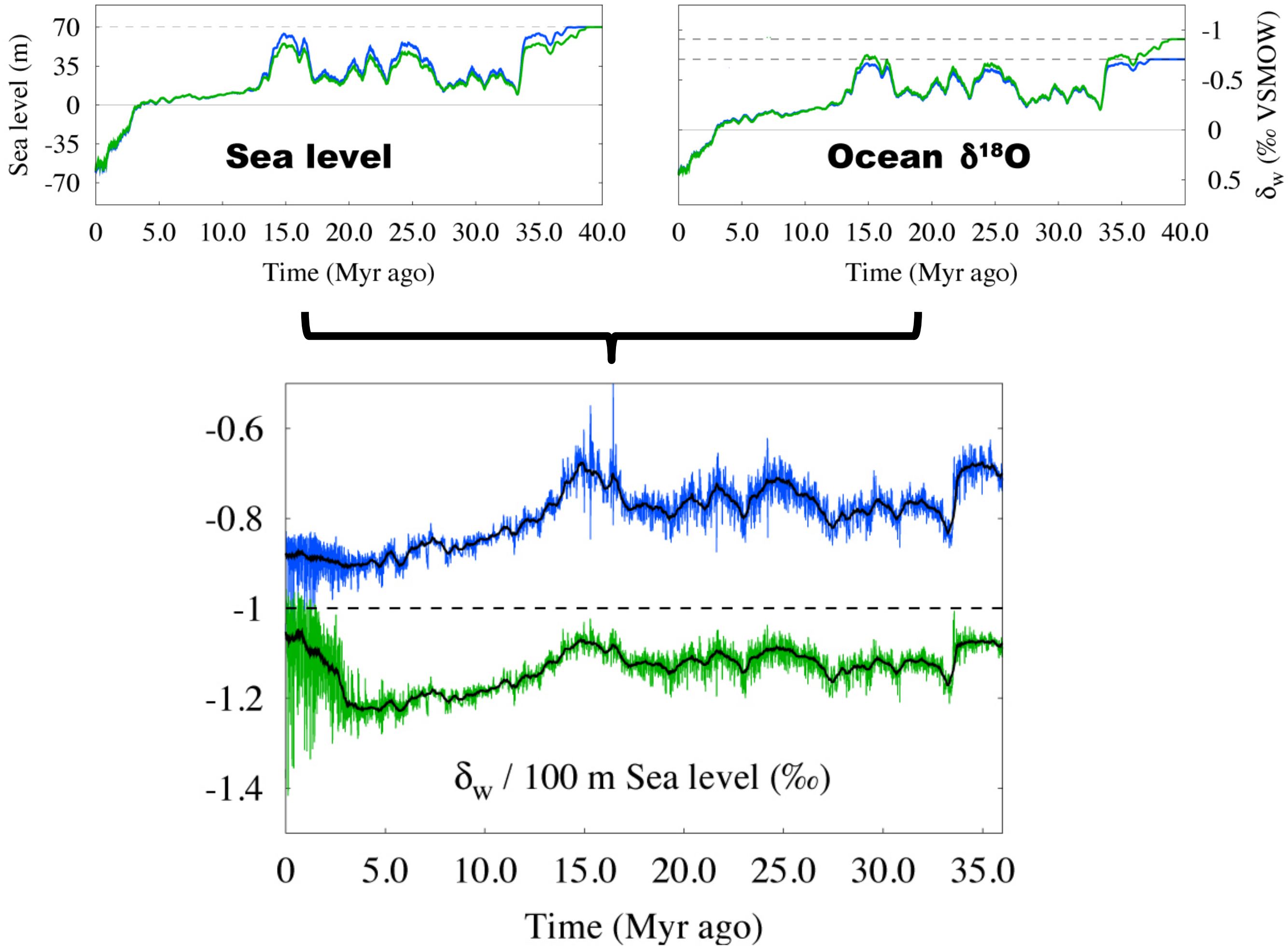
Variation in δ_w – sea level



Little changes in δ_w and sea level → large change in their ratio!

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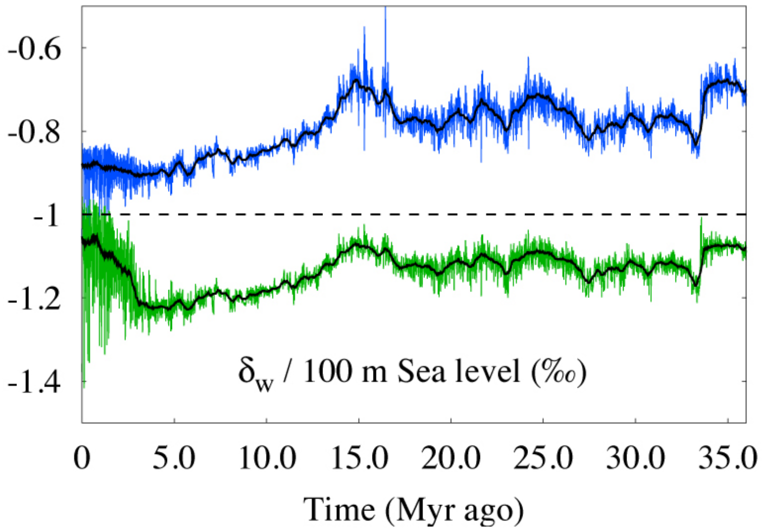
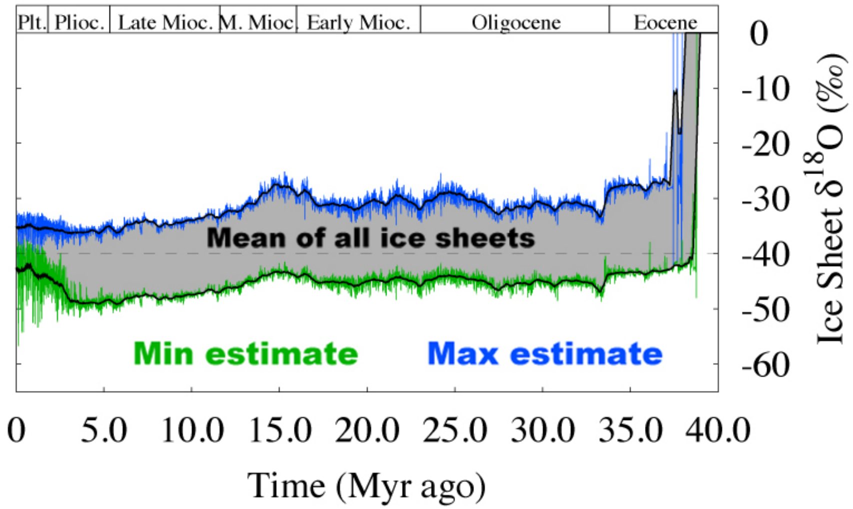
Using a constant δ_w to sea level ratio

- Commonly used in paleoclimate research
- Average value is ca. 1 ‰ per 100 meters sea level
- Corresponding mean $\delta^{18}O_{ice}$ = - 40 ‰





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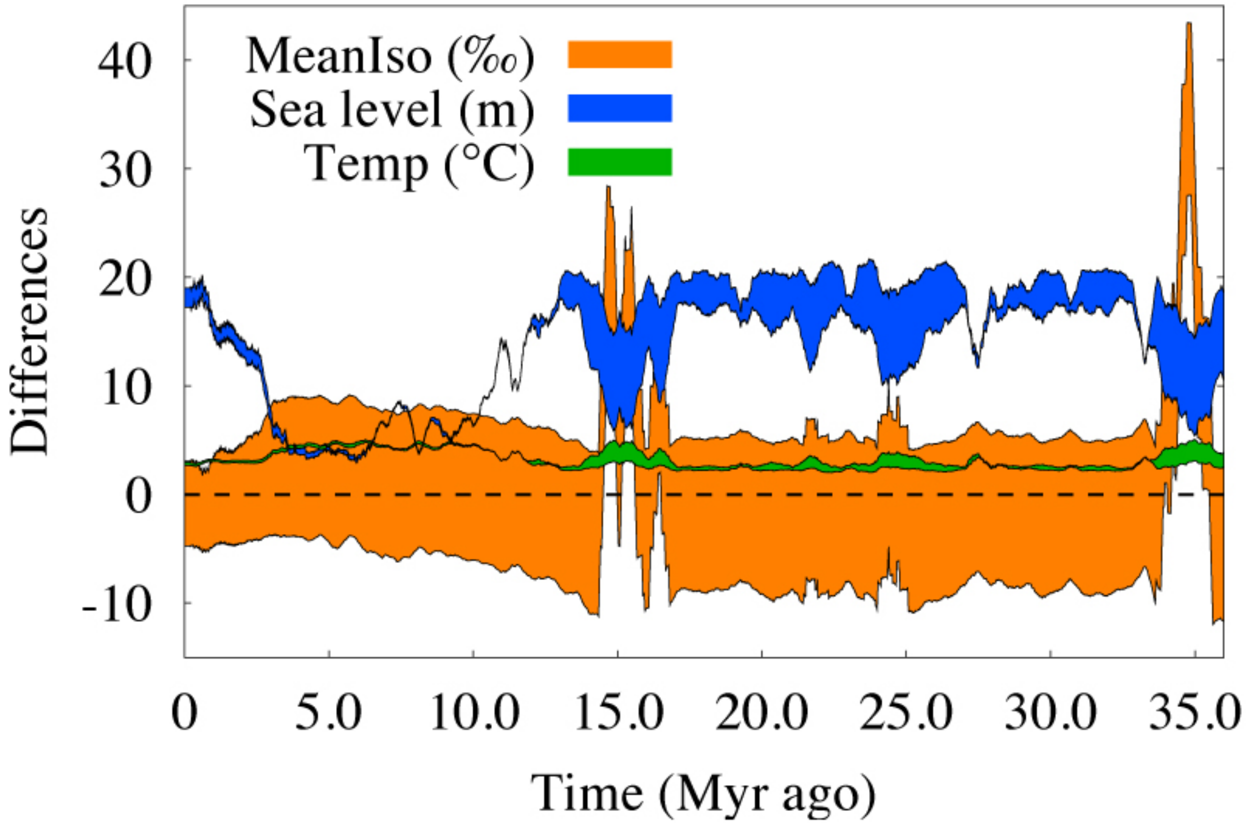
Using a constant δ_w to sea level ratio

Significant differences for sea level (blue) and

$\delta^{18}O_{ice}$ (orange: difference with -40 ‰)



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Importance of transient behaviour

- **A physical based approach is presented to separate the benthic δ^{18}O record**

- **Variable Ice volume-temperature sensitivity**

  The AIS is shown to be most sensitive to temperature change (during Oligocene, Early Miocene)

- **Large differences when using a constant δ_w to sea-level ratio**

  Notably affects interpretation of the benthic δ^{18}O records

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Commercial break

Please consider the following posters:

Session CL1.2 – Hall X/Y – XY181 – Today from 17.30 to 19.00

Pliocene Ice Sheet Modelling Intercomparison Project: PLISMIP - Simulating the Antarctic and Greenland ice sheets in the mid-Pliocene warm period

Aisling Dolan, Sebastian Koenig, Daniel Hill, Robert DeConto, and Alan Haywood

Session SSP2.1 – Hall A – A487 – Wednesday from 17.30 – 19.00

Dynamics of ~100-kyr glacial cycles during the early Miocene

Diederik Liebrand, Lucas J. Lourens, David A. Hodell, Bas de Boer, Roderik van de Wal, Heiko Pälike, and Samantha J. Gibbs

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Thank you for your attention

Further reading:

Bintanja, R. and R. S. W. van de Wal, 2008: *Nature*, **454**, 869-872

De Boer, B., R. S. W. van de Wal, R. Bintanja, L. J. Lourens and E. Tuenter, 2010: *Annals of Glaciology*, **51 (55)**, 23-33.

De Boer, B., R. S. W. van de Wal, L. J. Lourens and R. Bintanja, 2011: *Palaeogeography, Palaeoclimatology, Palaeoecology,* **in press**

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